PATENT ABSTRACTS OF JAPAN

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(54) MANUFACTURE OF COMPOSITE SINTERED MACHINE PARTS

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain high joining strength by forming a member made of steel material and having a shaft and a green compact composed of ferrous alloy powder or powder mixture and having a hole, fitting the shaft and the hole together, and carrying out integral sintering with use of the green compact having a composition where the amount of thermal expansion at a specific temperature at sintering is smaller than the amount of thermal expansion of the steel material.
SOLUTION: A green compact, whose amount of thermal expansion at ≥800° C at sintering is smaller than the amount of thermal expansion of a steel material, is used. As for a fit tolerance between the hole of an outer member and the shaft of an inner member, running fit of ≤5 μm clearance or close fit of ≤60 μm interference is preferred. It is preferable that a raw material powder constituting the green compact is composed of pure iron or has a composition equal to that of the steel material and that a zinc-free lubricant is used as a lubricant to be added to the raw material powder. Further, it is preferable to carry out sintering in gaseous nitrogen of noncarburizing atmosphere or in an atmosphere composed essentially of geseous nitrogen. Although sintering is ordinarily performed by solid phase sintering, diffusion joining can be further accelerated when sintering is done is a state where liquid phase is generated in part.

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(54)【発明の名称】　複合焼結機械部品の製造方法

(57)【要約】
【課題】　鉄系の焼結合金を製造する際、粉末潤滑材にはステアリン酸亜鉛が，また焼結雰囲気にはＦｅ－Ｃ系に向く精製エキソサーミックガスが広く用いられている。しかし、鋼材の外周に圧粉体を嵌め合わせて焼結により一体に接合する複合部品の場合は、この条件で焼結しても十分な接合強度は得られなかった。
【解決手段】　粉末潤滑材は亜鉛を含まないものに，焼結雰囲気は窒素ガスなど非浸炭性のものに変更することにより、焼結中に生じる圧粉体の膨脹量を鋼材の膨脹量以下に抑制した。この結果両部材が密着状態で焼結されて一体化し、接合強度が著しく向上した。

【特許請求の範囲】

【請求項１】　鋼材（溶製材）から形成された軸部を有する部材（以下内側部材という）と、鉄系の合金粉末または混合粉を圧縮成形して得た孔部を有する圧粉体（以下外側部材という）とを、それぞれの軸部と孔部を嵌め合わせた状態で一体に焼結するに際し、焼結過程の８００℃以上の高温域における熱膨張量が鋼材の熱膨張量よりも小さくなる組成の圧粉体を用いることを特徴とする、複合焼結機械部品の製造方法。

【請求項２】　外側部材の孔部と内側部材の軸部との嵌め合い寸法差が隙間５μｍ以下の通り嵌めもしくは締め代６０μｍ以内の締まり嵌めである、請求項１に記載の複合焼結機械部品の製造方法。

【請求項３】　圧粉体を構成する原料粉末が純鉄もしくは鋼材と同等組成のものである請求項１または請求項２に記載の複合焼結機械部品の製造方法。

【請求項４】　焼結を非浸炭性雰囲気で行なう、請求項１，請求項２または請求項３に記載の複合焼結機械部品の製造方法。

【請求項５】　焼結雰囲気が窒素ガス，または窒素ガスを主成分とするものである請求項４に記載の複合焼結機械部品の製造方法。

【請求項６】　原料粉末に添加する粉末潤滑剤として亜鉛を含有しないものを用いる、請求項１，請求項２または請求項３に記載の複合焼結機械部品の製造方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】この発明は、形状の複雑な焼結機械部品の製造に用いられる複数の部分に分割成形した圧粉体を組み合わせて焼結することにより１箇の焼結部品を得る方法を応用した、圧粉体の部分と鋼材（溶製材）の部分とを焼結により接合する方法の改良に関するものである。

【０００２】

【従来の技術】複数の圧粉体を組み合わせて１箇の焼結部品とするためには、一方の圧粉体は軸部を有する形状に，他方の圧粉体は孔部を有する形状に成形しておき、軸部を有する部材（嵌め合わせで内側になることから、以下内側部材という）と孔部を有する部材（以下外側部材という）の軸部と孔部を嵌め合わせた状態で焼結して拡散接合により一体化させるのが通例である。そして焼結合金はその成分組成によって焼結中の熱膨張量がそれぞれ異なるので、内側部材，外側部材ともに圧粉体の場合は、外側部材の熱膨張量が内側部材より小さくなるように両部材を選択して、両部材が密着した状態での焼結を図っている。

【０００３】この様にして作られる複合焼結機械部品の多くは圧粉体同士を接合したものであるが、中には部品の用途，機能面その他の必要から外側部材は焼結合金（圧粉体）のまま、内側部材には鋼材（溶製材）を使用

したい場合がある。ところで、焼結合金も同素変態および熱による寸法変化を示すことは溶製材の場合と同様であるが、焼結合金に特有の現象として圧粉体からの焼結過程で粉末粒子の隙間の気孔化～気孔の消失による緻密化（収縮）を生じるので、普通に焼結した場合の熱膨張量は同等組成の鋼材に比べて原則的に小さくなる。

【０００４】従って、外側部材（圧粉体）の方が相対的に収縮して内側部材（鋼材）と密着するので両部材は十分接合される筈であり、事実圧粉体同士の場合は合金成分の拡散が進行して高い接合強度が得られるにも拘らず、内側部材が鋼材の場合には量産を前提とした通常の焼結条件では所要の接合強度は得られない。この場合も焼結条件を変更し、高温で長時間の焼結を行なえば接合強度は向上するが、生産効率とコストの面で実用にはなり難かった。

【０００５】

【発明が解決しようとする課題】そこでこの対策として、圧粉体と嵌め合わせる前に鋼材の接合面に浸炭処理を施しておく接合方法が開発された。この方法は、圧粉体の炭素含有量よりも高い濃度の浸炭層を鋼材表面に形成しておくと焼結時に浸炭層から圧粉体への炭素の拡散が充分に進行し、圧粉体同士の場合と同様の高い接合強度が得られるという現象を利用したものである。

【０００６】しかし、この方法にはイオン浸炭法などの浸炭処理を長時間施す必要があり、鋼材の処理コストが高くつくこと，浸炭を好まない場合や浸炭に向かない材質があるため、実施の対象が制約されるなどの問題があった。この発明は圧粉体との焼結による接合に際し鋼材の浸炭処理を要しない方法の開発を目的とするものであり、とくに内側部材が鋼材，外側部材が圧粉体という組み合わせを対象としている。ちなみにこの明細書における鋼材は純鉄，炭素鋼，合金鋼など鉄系金属の溶製材を総称している。

【０００７】

【課題を解決するための手段】圧粉体の外側部材に鋼材の内側部材を嵌め合わせて焼結接合する場合、得られる複合部品が高い接合強度を持つためには単なる機械的な焼き嵌めだけでなく、両部材の接合面が十分に密着した状態での焼結によって、合金成分の固相拡散による接合を図る必要がある。それには先ず、両部材を嵌め合わせる際の嵌め合い寸法差（圧粉体の孔部の内径寸法と鋼材の軸部の外径寸法の差）が重要で、圧粉体の方を細め（締まり嵌め）に設定して鋼材に圧入するのが好ましく、締め代は大きいほど両者の密着度が高くなる。ただし焼結前で強度が低い圧粉体の破損を避けるため、締め代を緩衝作用のある圧粉体同士の場合より小さく、好ましくは３０μｍ以内，多くとも６０μｍ以内に止める必要がある。通り嵌めを選ぶ場合も隙間は小さいほどよく、５μｍ以下に止めるべきである。

【０００８】次の要因として焼結する際の雰囲気の種

類、および雰囲気と圧粉体に配合する粉末潤滑材の種類との関連がある。即ち、鉄系合金の焼結雰囲気としては高炭素のＦｅ－Ｃ系に向き、しかもとくに忌避すべき材質もないことから、天然ガスやメタン系炭化水素などを変成して作られる精製エキソサーミックガスが広く用いられ、また、粉末潤滑材にはステアリン酸亜鉛が一般的に使用されている。

【０００９】ところが圧粉体を外側部材，鋼材を内側部材とする複合焼結の場合にこの様な雰囲気（例えばブタン変成ガス）を使用すると、雰囲気中の炭素が気孔表面から鉄中に侵入して反応し、本来鋼材ほど膨脹しない筈の圧粉体を膨脹させること，その際圧粉体中に亜鉛が存在すると、この反応に対して微量で触媒作用を示して膨脹量を増大させることが判明した。この膨脹のために圧粉体と鋼材との密着が不十分になり、接合強度の低下を招く訳である。

【００１０】従ってこの対策としては粉末潤滑剤を亜鉛を含まないもの、例えばステアリン酸リチウムその他亜鉛以外の金属ステアレイトまたはアクラワックス（商品名）などに変えて膨脹を軽減することと、根本的には雰囲気ガスを非浸炭性のものに変えることが必要である。その場合、経済性も考慮すると非浸炭性ガスの中でも殆ど不活性に近い窒素ガス雰囲気，または窒素ガスを主成分とする雰囲気が特に好ましい。また焼結は固相焼結によるのが通常であるが、一部に液相を生成する状態で焼結すると拡散接合がさらに促進される。その場合、液相の生成量が５％以内であれば浸蝕や形崩れなどの懸念はないが、焼結体の寸法精度も良好な状態に保つためには３％以内に止めることが好ましい。なおこの明細書中の組成等に関する％は、特に断らない限り重量％である。

【００１１】

【発明の実施の形態】（実施例１）　先ず炭素鋼Ｓ４５Ｃで外径３０ｍｍ，内径１０ｍｍ，長さ２０ｍｍの円筒を作製して内側部材とした。次に銅粉１．５％および黒鉛粉０．７％を鉄粉に配合し、これに粉末潤滑剤としてアクラワックス（商品名）を０．７％添加した混合粉を用意した。この粉末を圧縮して内径３０ｍｍ，外径４０ｍｍ，長さ１０ｍｍで圧粉密度７．０ｇ／ｃｍ³ の円板状の圧粉体を形成し、外側部材とした。次いで両部材を締め代３０μｍの圧入により嵌め合わせ、窒素雰囲気中１１３０℃で４０分間焼結し、一体に接合した。得られた焼結体を材料試験機に掛け、外側部材を架台上に支えて内側部材に負荷する破壊試験を行なった結果、両部材の接合強度は１２０ＭＰａであった。

【００１２】（実施例２）　先ず実施例１における内側部材の材質を炭素鋼から機械構造用鋼ＳＣＭ４１５に変更し、外側部材は、圧粉体を形成する原料粉をヘガネス社の銅…１．５％，Ｎｉ…４％，Ｍｏ…０．５％および残部Ｆｅの部分拡散合金粉末（商品名デスタロイＡＥ）に変更した。粉末潤滑剤および圧粉密度は実施例１と同じである。次いで両部材を締め代２０μｍの圧入により嵌め合わせ、分解アンモニアガス雰囲気中１１９５℃で１１５分間焼結して一体に接合した。得られた焼結体について実施例１と同様に破壊試験を行なった結果、両部材の接合強度は２００ＭＰａであった。

【００１３】（実施例３）　内側部材の材質は実施例２のまま（ＳＣＭ４１５）とし、外側部材は圧粉体を形成する原料粉をＮｉ…２％，Ｍｏ…１．５％および残部Ｆｅの組成の合金粉に黒鉛を０．６％配合した混合粉に変更した。次いで両部材を締め代２０μｍの圧入により嵌め合わせ、分解アンモニアガス雰囲気中１１９５℃で１５分間焼結して一体に接合した。得られた焼結体について実施例１と同様に破壊試験を行なった結果、両部材の接合強度は２００ＭＰａであった。

【００１４】ちなみに、外側部材（圧粉体）の機械的性質としては焼結中の熱膨張量が内側部材（鋼材）より小さければよいので、その材質は実施例の組成に限らず、純鉄でもよく内側部材の鋼材と同じ材質でもよい。また熱膨張量を（鋼材より）増大させない限り、用途に応じた適宜の合金成分を含有させることができる。

【００１５】（比較例１）　合金組成および形状寸法は実施例１のものと同一で、粉末潤滑剤のみステアリン酸亜鉛０．７％に変更した圧粉体を作製し、この外側部材と、実施例１の場合と同一の内側部材（鋼材）とを締め代３０μｍの圧入により嵌め合わせ、炉の雰囲気を浸炭性のブタン変成ガスに変更し、１１３０℃で４０分間焼結した。しかし、得られた焼結体には両部材の接触面に接合しなかった部分が認められ、強度的にも不良品であった。

【００１６】（比較例２）　圧粉体の粉末潤滑剤としてアクラワックス（商品名）を用いたこと以外は比較例１の場合と同じ条件で処理したところ、得られた焼結体の接合強度は４０ＭＰａで、接合してはいるが強度不足であった。

【００１７】

【発明の効果】鋼材を内側部材，鉄系焼結合金を外側部材とする複合部品の場合、従来の製造条件では両部材の強固な接合はできなかったが、この発明によって粉末潤滑剤と焼結雰囲気の適正組み合わせが明確になり、その結果両部材の接合強度が著しく高められた。

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CLAIMS

[Claim(s)]
[Claim 1] The member which has the shank formed from steel materials (ingot material) (henceforth an inside member), The green compact (henceforth lateral part material) which has the pore which pressed and obtained the alloy powder or mixed powder of an iron system The manufacture approach of the concurrent-sintering machine part which faces sintering to one where each shank and pore are inserted in, and is characterized by using the green compact of the presentation to which the amount of thermal expansion in the pyrosphere 800 degrees C or more of a sintering process becomes smaller than the amount of thermal expansion of steel materials.
[Claim 2] as [of the pore of lateral part material, and the shank of an inside member] inserting each other in and variation of tolerance being 5 micrometers or less of clearances -- inserting in -- or the manufacture approach of the concurrent-sintering machine part of less than 60 micrometers of interferences according to claim 1 which it is closed, inserts in and comes out and exists.
[Claim 3] The manufacture approach of a concurrent-sintering machine part according to claim 1 or 2 that the raw material powder which constitutes a green compact is the thing of pure iron or steel materials, and an equivalent presentation.
[Claim 4] The manufacture approach of claim 1 which sinters in an un-carburizing nature ambient atmosphere, and a concurrent-sintering machine part according to claim 2 or 3.
[Claim 5] The manufacture approach of the concurrent-sintering machine part according to claim 4 which is that to which a sintered atmosphere uses nitrogen gas or nitrogen gas as a principal component.
[Claim 6] The manufacture approach of claim 1 using what does not contain zinc as powder lubricant added to raw material powder, and a concurrent-sintering machine part according to claim 2 or 3.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to amelioration of the approach of joining the part of a green compact and the part of steel materials (ingot material) adapting the approach of obtaining one sintering component, by sintering by sintering combining the green compact which carried out division shaping into two or more parts used for manufacture of sintered machine parts with a complicated configuration.
[0002]
[Description of the Prior Art] In order to consider as one sintering component combining two or more green compacts In the configuration in which one green compact has a shank, the green compact of another side is fabricated at the configuration which has a pore. It is usually to sinter, where the shank and pore of the member (it is called a following inside member since it inserts in and becomes inside by doubling) which has a shank, and the member (henceforth lateral part material) which has a pore are inserted in, and to make it unify by diffused junction. And with the component presentation, since the amounts of thermal expansion under sintering differ, respectively, the sintered alloy is aiming at sintering in the condition that chose both members and both members stuck them so that the amount of thermal expansion of lateral part material might become [as for an inside member and lateral part material] smaller than an inside member in the case of a green compact.
[0003] Thus, although many of concurrent-sintering machine parts made join green compacts, lateral part material has in inside the case where he wants to use steel materials (ingot material) in an inside member from the application of components, and the need for a functional side and others with a sintered alloy (green compact). By the way, although it is the same as that of the case of ingot material that a sintered alloy also shows allotropic modification and the dimensional change by heat, since the eburnation (contraction) by disappearance of pore-izing of the clearance between powder particles - pore is produced in the sintering process from a green compact as a phenomenon peculiar to a sintered alloy, the amount of thermal expansion at the time of sintering ordinarily becomes small in principle compared with the steel materials of an equivalent presentation.
[0004] Therefore, since the direction of lateral part material (green compact) contracts relatively and it sticks with an inside member (steel materials), both members should be joined enough, and in spite of diffusion of an alloy content advancing in the case of fact green compacts and obtaining high bonding strength, when inside members are steel materials, necessary bonding strength is not obtained on the usual sintering conditions on condition of mass production. Although bonding strength improved when changing sintering conditions also in this case and sintering long duration at the elevated temperature, it was hard to become practical use in respect of productive efficiency and cost.
[0005]
[Problem(s) to be Solved by the Invention] Then, as this cure, before inserting in with a green compact, the junction approach of performing carburization processing to the plane of composition of steel materials was developed. If the carburization layer of concentration higher than the carbon content of a green compact is formed in the steel-materials front face, diffusion of the carbon from a carburization layer to a green compact will fully advance at the time of sintering, and this approach

uses the phenomenon in which the same high bonding strength as the case where they are green compacts is obtained.
[0006] However, carburization processing of an ion cementation process etc. needed to be performed to this approach for a long time, and since there was the quality of the material which is fit for neither the case where the processing cost of steel materials costing dearly and carburization are not liked, nor carburization, there was a problem of the object of operation being restrained. This invention is aimed at the combination of a green compact in steel materials and lateral part material by especially the inside member for the purpose of development of the approach of not requiring carburization processing of steel materials on the occasion of junction by sintering with a green compact. Incidentally the steel materials in this specification have named generically the ingot material of iron system metals, such as pure iron, carbon steel, and alloy steel.
[0007]
[Means for Solving the Problem] When the inside member of steel materials is inserted in the lateral part material of a green compact and carries out sinter bonding to it, in order for the composite part obtained to have high bonding strength, it is necessary to aim at junction by solid phase diffusion of an alloy content by sintering in the mere mechanical condition that burned and inserted in and the plane of composition of both the members instead of **** fully stuck. It inserts each other in it at the time of inserting in both members first, variation of tolerance (difference of the inside diameter of the pore of a green compact and the outer-diameter dimension of the shank of steel materials) is important, it is desirable to set up for narrowing the green compact (closing and inserting in), and to press fit in steel materials, and both degree of adhesion becomes high, so that an interference is large. However, it is before sintering, and in order to avoid breakage of a green compact with low reinforcement, it is smaller than the case of green compacts with buffer action, and it necessary to stop an interference within less than 30 micrometers and at most 60 micrometers preferably. Also when it passes and chooses eye **, a clearance is so good that it is small, and should be stopped to 5 micrometers or less.
[0008] There is relation with the class of ambient atmosphere at the time of sintering as a following factor and the class of powder lubricant blended with an ambient atmosphere and a green compact. That is, since there is also no quality of the material which should be evaded especially moreover toward the Fe-C system of high carbon as a sintered atmosphere of an iron system alloy, purification exosir MIKKUGASU made by carrying out conversion of natural gas, the hydrocarbon of methane series, etc. is used widely, and, generally zinc stearate is used for powder lubricant.
[0009] However, if such an ambient atmosphere (for example, butane converted gas) is used in the case of concurrent sintering which uses a green compact lateral part material and uses steel materials as an inside member From the pore front face, the carbon in an ambient atmosphere invaded into iron, and reacted, and it became clear that a minute amount would show a catalysis to this reaction, and the amount of expansion would be increased if zinc exists in a green compact in to expand the green compact to which steel materials more originally should not expand, and that case. For this expansion, adhesion with a green compact and steel materials becomes inadequate, and causes the fall of bonding strength.
[0010] Therefore, it is required to change powder lubricant into metal stearate or the Accra waxes (trade name) other than what [what does not contain zinc], for example, lithium stearate and other zinc, etc. as this cure, and to mitigate expansion, and to change a controlled atmosphere into the thing of un-carburizing nature fundamentally. In that case, when economical efficiency is also taken into consideration, the nitrogen-gas-atmosphere mind almost near inactive or especially the ambient atmosphere that uses nitrogen gas as a principal component is desirable also in un-carburizing nature gas. Moreover, although sintering is usually based on solid phase sintering, if it sinters in the condition of generating the liquid phase to a part, diffused junction will be promoted further. In that case, if the amount of generation of the liquid phase is less than 5%, there will be no concern of erosion, form collapse, etc., but in order to also maintain the dimensional accuracy of a sintered compact at a good condition, stopping within 3% is desirable. In addition, especially % about the presentation in this specification etc. is weight % unless it refuses.
[0011]
[Embodiment of the Invention] (Example 1) The cylinder with the outer diameter of 30mm, a bore

[of 10mm], and a die length of 20mm was first produced by carbon steel S45C, and it considered as the inside member. Next, 1.5% of copper powder and 0.7% of graphite powder were blended with iron powder, and the mixed powder which added the Accra wax (trade name) 0.7% as powder lubricant to this was prepared. This powder is compressed and it is green density 7.0 g/cm3 at the bore of 30mm, the outer diameter of 40mm, and die length of 10mm. The disc-like green compact was formed and it considered as lateral part material. Subsequently, both members were inserted in by press fit of 30 micrometers of interferences, and it sintered for 40 minutes at 1130 degrees C among nitrogen-gas-atmosphere mind, and joined to one. As a result of performing the breakdown test which hangs the obtained sintered compact on a material testing machine, supports lateral part material on a stand, and carries out a load to an inside member, the bonding strength of both members was 120MPa(s).

[0012] (Example 2) It is [-- It changed into the partial diffusion alloy powder (trade name DESUTAROI AE) of 0.5% and Remainder Fe.] copper of HEGANESU about the raw material powder with which the quality of the material of the inside member in an example 1 is first changed into steel for machine structural use SCM 415 from carbon steel, and lateral part material forms a green compact. -- They are 1.5% and nickel. -- They are 4% and Mo. Powder lubricant and green density are the same as an example 1. Subsequently, both members were inserted in by press fit of 20 micrometers of interferences, and it sintered for 115 minutes at 1195 degrees C among the decomposition ammonia gas ambient atmosphere, and joined to one. As a result of performing a breakdown test like [sintered compact / which was obtained] an example 1, the bonding strength of both members was 200MPa(s).

[0013] (Example 3) It is nickel about the raw material powder with which the quality of the material of an inside member is considered as as [an example 2] (SCM415), and lateral part material forms a green compact. -- They are 2% and Mo. -- It changed into the mixed powder which blended the graphite with the alloy powder of a presentation of 1.5% and Remainder Fe 0.6%. Subsequently, both members were inserted in by press fit of 20 micrometers of interferences, and it sintered for 115 minutes at 1195 degrees C among the decomposition ammonia gas ambient atmosphere, and joined to one. As a result of performing a breakdown test like [sintered compact / which was obtained] an example 1, the bonding strength of both members was 200MPa(s).

[0014] Incidentally, since the amount of thermal expansion under sintering should be just smaller than an inside member (steel materials) as a mechanical property of lateral part material (green compact), not only the presentation of an example but pure iron is sufficient as the quality of the material, and the same quality of the material as the steel materials of an inside member is sufficient as it. Moreover, unless the amount of thermal expansion is increased (steel materials), the proper alloy content according to an application can be made to contain.

[0015] (Example 1 of a comparison) The alloy presentation and the geometry were the same as that of the thing of an example 1, produced the green compact which changed only powder lubricant into 0.7% of zinc stearates, inserted in this lateral part material and the same inside member as the case of an example 1 (steel materials) by press fit of 30 micrometers of interferences, changed the ambient atmosphere of a furnace into the butane converted gas of carburization nature, and sintered it for 40 minutes at 1130 degrees C. However, the part which was not joined to the obtained sintered compact in the contact surface of both members was accepted, and it was a defective also in reinforcement.

[0016] (Example 2 of a comparison) When processed on the same conditions as the case of the example 1 of a comparison except having used the Accra wax (trade name) as powder lubricant of a green compact, the bonding strength of the obtained sintered compact was 40MPa(s), and reinforcement was insufficient [bonding strength] although it had joined.

[0017]

[Effect of the Invention] In the case of the composite part which makes an inside member and an iron system sintered alloy lateral part material, on the conventional manufacture conditions, firm junction of both members was not able to do steel materials, but the proper combination of powder lubricant and a sintered atmosphere became clear, and, as a result, the bonding strength of both members was remarkably raised by this invention.

[Translation done.]